## Chapter 3

# ASSESSMENT OF THE IMPACT OF MECHANICAL RECOVERY IMPROVEMENTS ON RESPONSE CAPABILITY

***In this chapter:***

- ***How far have mechanical recovery systems and equipment, as well as supporting spill surveillance technology, advanced since the Caps regulations were formulated?***
- ***Are modern mechanical recovery equipment and systems readily available for purchase on the open market?***
- ***Are there sufficient mechanical recovery resources available around the country at present, or with a reasonable addition of resources, to meet the proposed Caps level increases?***
- ***Is an increase in mechanical recovery Caps levels practicable in light of advances in technology, market availability of systems and equipment, and overall distribution of mechanical recovery resources around the nation?***

When formulating equipment requirement Caps for vessels and facilities as specified in 33 CFR 155 and 33 CFR 154, respectively, mechanical recovery was considered the primary cleanup technique. It is therefore essential to analyze the overall improvement in mechanical recovery capability since 1993 carefully to determine whether an initial increase in the current Caps and another in 5 years are practicable. Although 33 CFR 155.1050(p) and 33 CFR 154.1045(n) require that the USCG consider other technologies as part of this review, it is clear from the data in Chapter 2 that mechanical recovery remains the mainstay of any response planning.

To evaluate mechanical recovery status, this Caps review focuses on open-water recovery of Groups I through IV oils (as defined in 33 CFR 155.120) as the primary indicator of overall improvement. Although the recovery of Group V oils has become a topic of interest in recent years, the recovery techniques and equipment for these oils are not well developed, and Caps have not been established for such oils under the current regulations (per 33 CFR 155.1052 and 33 CFR 154.1047). Mechanical recovery of oil from shorelines also will not be discussed, even though oil removal from shorelines is often a necessary and intensive aspect of oil spill response. In addition, shoreline cleanup can involve a myriad of techniques with widely varying levels of success, depending on oil type, shoreline type, and specific spill circumstances. Therefore, it would be difficult to assess overall improvements in shoreline cleanup since 1993 based on a quantitative analysis of the technology or spill case studies.

In assessing the need to raise the current Caps by an initial 25% (and another 25% in 5 years), the USCG must assess vessel and facility plan holders' current capability to implement the complete oil recovery process as compared with the capability in 1993. In doing so, three important topics must be considered: technological capability, equipment availability, and deployment and operation of equipment at generic spill locations (oceans, inland, Great Lakes, rivers and canals) within the prescribed time limitations (Tiers I, II, and III response times) throughout the United States.

Assessing ***technological capability*** involves reviewing advances in systems and equipment design and configuration over the past 5 years to highlight significant improvements that support an increase in the current Caps. The technology assessment focuses on oil spill surveillance systems; offshore and fast-water booms and skimming devices; oil/water separation and emulsion-breaking systems; and modular, easily transported, temporary storage devices.

Assessing ***equipment availability*** improvements involves reviewing equipment currently on the market (in terms of representative models and their intended applications) as compared with that available 5 years ago. The primary reference for this assessment is the fourth and sixth editions of the *World Catalog of Oil Spill Response Products* (Schulze, 1993, 1997; see also Appendix B). The *World Catalog* is reviewed to determine the number of new booms, skimmers, pumps, oil/water separation systems, and temporary storage devices on the market since 1993.

In addition, an assessment of immediate ***deployment and operation of equipment*** is made by reviewing nationwide inventories of major items—booms, skimmers, skimming vessels, and temporary storage devices and containers. The primary data were compiled using the National Strike Force Coordination Center's (NSFCC) Response Resource Inventory (RRI). Equipment distribution and the recovery capacity it represents are examined by geographic region to determine if current and proposed increases are achievable throughout the United States. An assessment also is made of the overall EDRC, represented by current equipment levels for different generic spill locations (oceans, inland, Great Lakes, rivers and canals) at specified response times (Tiers I, II, and III) throughout the country. The EDRC calculation specified in the regulations somewhat oversimplifies the mechanical recovery process by estimating oil recovery capability based on the mechanical oil recovery rate or de-rated pumping capacity of a skimmer. As indicated in Section 3.1, the overall mechanical recovery process is far more complex, involving other equipment, systems, and processes, each with inherent limitations; therefore, the EDRC values should be viewed as "optimistic" relative indicators of ability to recover oil.

Throughout this chapter, improvements in equipment technology and availability are noted. Based on these improvements in mechanical recovery technology, equipment availability, and overall recovery capability, recommendations are made regarding increases that can be supported initially and in 5 years.

## 3.1 MECHANICAL RECOVERY PROCESS

To assess improvements in on-water recovery capability, it is important to recognize that the mechanical recovery process is not limited to oil removal from the water surface. Instead, this process involves a sequence of steps by which oil is located, contained, recovered, processed, temporarily stored on-scene, and removed from a spill scene for disposal or reprocessing. This process is depicted in Figure 3-1.

First, oil must be located and mapped so that mechanical recovery equipment can be deployed and positioned effectively. Tracking and mapping a spill's extent and locating heavier concentrations of oil generally require aerial surveillance using fixed-wing aircraft or helicopters. Visual surveillance—the most common method of locating recoverable oil—is limited to daylight hours and good visibility. Remote-sensing systems (e.g., radar and infrared) have been developed to map the areal extent of a spill at night and in poor visibility. Infrared (IR) sensors and ultraviolet (UV) scanners provide qualitative information on the location of thicker portions of an oil slick. Currently, no available sensor measures slick thickness directly, which is the key parameter of interest in conducting skimming operations. Oil spill surveillance data must be available at both strategic and tactical levels. On the strategic level, the overall size and extent of a spill must be known so that the proper response resources can be assembled and deployed to a spill scene. Once at a spill scene, aerial spotting is required to direct response equipment to the higher oil concentrations. Since oil recovery success heavily depends on the ability to track and map a spill, 33 CFR 155.1050(p) and 33 CFR 154.1045(n) specifically require that oil spill tracking technology be addressed in this Caps review.

Before oil recovery operations begin, the necessary vessels and equipment must be transported to a spill scene, assembled, and deployed. The amount of time required to assemble and rig a containment and recovery system varies depending on a system's size and complexity. Suitable vessels must be acquired, and equipment must be loaded onboard, secured for transport, and rigged for operation once on-scene. Including transport time from loading point to spill scene, this process generally requires several hours to a day to complete. This, too, is a critical step in determining overall response outcome since recovery operations must be initiated before oil disperses over a wider area. Timely transport and deployment are reflected in the regulations by the increasing recovery capacity requirements within Tiers I, II, and III. These transport and deployment criteria can be met by pre-staging cleanup equipment near various potential spill scenes, or making equipment modular and air-transportable so that it can be moved rapidly to a spill scene from greater distances.

Once oil has been located, equipment must be deployed to contain and concentrate oil to a thickness that allows for mechanical removal using skimmers. The rate at which oil is made available to the skimming device—encounter rate—is often far more important in determining the success of a skimming operation than the inherent capability of the skimmers themselves. In harbor areas, oil often can be contained at a vessel or facility using conventional containment booms, which greatly improves recovery success. For offshore spills, oil often spreads over a wider area such that it must be collected and concentrated using oil containment booms towed through the spill area. The rate at which oil can be

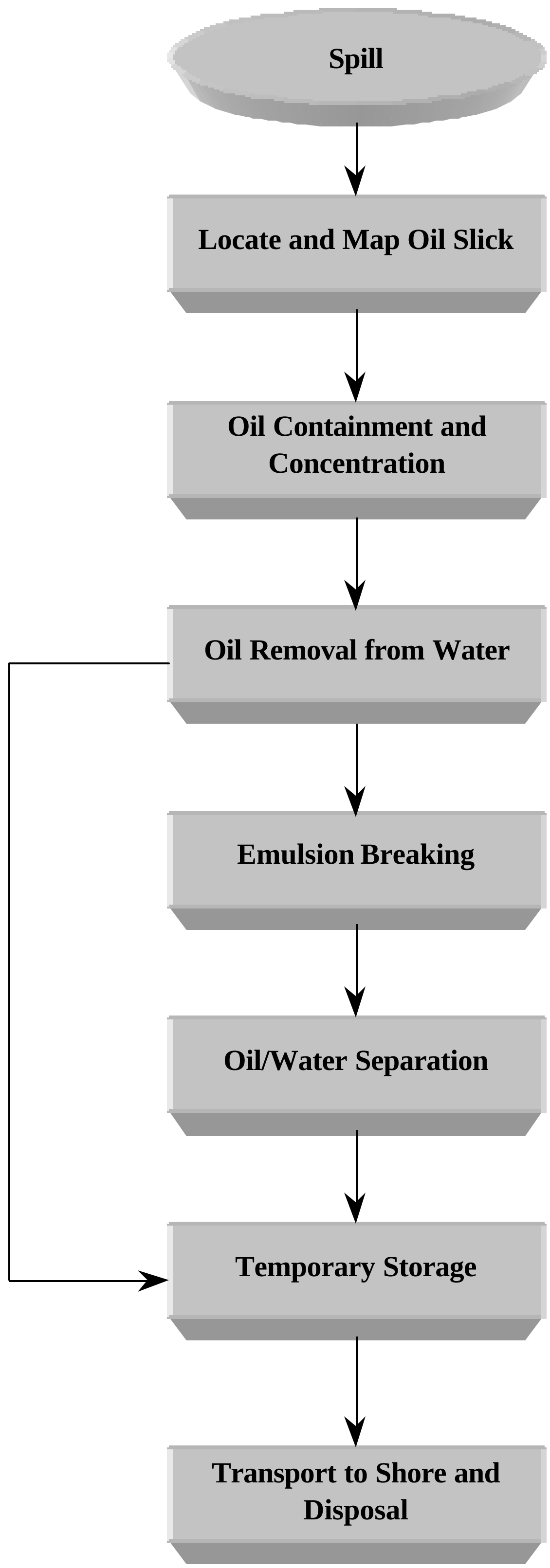


**FIGURE 3-1.** Schematic of the Mechanical Recovery Process.

collected in open-water, offshore operations is a function of the relative speed of advance through a slick (generally1 kt or less), and sweep width of the boom/skimmer combination (also referred to as the gap width or mouth opening). Collection rates generally decrease with increasing sea states. Depending on boom characteristics, sea states of 3 to 4 (waves 4 ft to 8 ft) generally represent the upper limits of boom effectiveness. Although boom durability and deployment ease have improved over the years, tow speed and seakeeping ability continue to be fundamental constraints. Collecting and concentrating oil in fast currents are challenging and often impractical at speeds above 3 kts.

Assuming that sufficient oil is made available to skimming devices, the success of a recovery operation is limited by the capability of a skimming device to remove oil from the water surface. The key parameter of interest in assessing oil skimming system performance is the oil recovery rate (ORR), which is the rate pure oil is being recovered (expressed in gallons per minute [gpm], barrels per day [bpd], etc.). ORR generally is less than encounter rate (total rate at which oil is made available to a boom and/or skimmer). The ratio of oil recovered to oil encountered is throughput efficiency, which is expressed as a percentage. ORR for skimming vessels can be measured directly either in a full-scale spill response test tank that allows for performance testing with oil (such as at the national oil spill response test facility in Leonardo, New Jersey—Oil and Hazardous Material Simulated Environment Test Tank or OHMSETT) or in actual recovery operations if all parameters are monitored carefully.

If properly documented ORR values for a skimming device are available, the regulations allow for their use in calculating overall recovery capacity. Obtaining ORR data, however, requires significant effort by government agencies or manufacturers such that actual test data are not available for many skimming systems. Because of this, 33 CFR 155 and 33 CFR 154 also allow for estimating ORR as 20% of a manufacturer's claimed recovery capacity (nameplate capacity), which for most skimmers is 20% of a device's fluid pumping capacity. The 20% factor adjusts the device's nameplate capacity for variables such as degree of emulsification, weather conditions, available daylight hours, and sea state that reduce the encounter rate and oil recovery efficiency (ORE). The calculations, however, assume that encounter rate is not a limiting factor (that is, oil is continuously contained, concentrated and presented to a skimmer at a rate that equals 20% of the pumping capacity). The calculations also assume that ample deployment vessels and supporting equipment are available to deliver a skimming device on-scene, and operate and maintain it on a continuous basis. Both of these assumptions are very optimistic for most spill situations, such that the oil recovery values calculated using this formula represent best case estimates.

Once oil has been removed from the water surface, it must be stored temporarily and transported to shore for offloading and final disposition. In most cases, recovered oil must be transferred from a very small storage tank on a skimming device to a larger storage vessel or device (e.g., a barge or oil storage bladder) for transport to shore. Recovered oil storage capacity on a skimming vessel and ability to transfer recovered oil rapidly to a tank vessel at sea are factors that can limit the effectiveness of high-capacity skimming systems. There have been several significant spills in which recovery operations were delayed or suspended because oil storage, transfer, and transport issues had not been addressed adequately. These issues are especially prevalent with vessel-of-opportunity skimming systems (VOSSs) that may be placed on vessels with no inherent oil storage capacity.

An intermediary step in transferring and storing recovered oil/water mixture often is pre-processing the mixture to remove water through de-emulsification and/or oil/water separation. Effective de-emulsification and oil/water separation systems can reduce recovered mixture volumes by a factor of five or more. The capability generally is available only on large oil spill recovery vessels (OSRVs) with installed skimming systems that include integral storage tanks, installed high capacity oil/water separators, and de-emulsification injection systems. Such de-emulsification and separator systems also could be installed or deck mounted on oil storage barges if portable systems are available.

The regulations account for temporary oil storage by requiring that available storage capacity contracted by a vessel or facility plan holder be twice the calculated EDRC. The regulations assume that an equal amount of water will be recovered with oil and must be stored and transported with oil to shore. Improvements in oil/water separation and de-emulsification technology will increase the amount of pure oil that can be transported to shore by storage barges or skimmers. Advances in easily transportable, temporary storage devices (e.g., collapsible barges and bladders) allow rapid augmentation of temporary storage and transport capability.

The final step in the mechanical recovery process is the disposal or re-processing of recovered oil such that it no longer presents a (short-term or long-term) threat to the environment. There are no specific requirements in 33 CFR 155 and 33 CFR 154 for ensuring this capability other than addressing it in local contingency plans.

Having described this process, it is important to recognize that it involves a series of steps, each requiring different types of equipment and procedures. Difficulties in carrying out any one step will cause a “bottleneck” in the process and decrease the amount of oil that is actually recovered, despite the fact that specific pieces of equipment (e.g. booms, skimmers, temporary storage devices, and oil/water separators) may be highly capable in their own right.

## 3.2 RECENT ADVANCES IN TECHNOLOGY DEVELOPMENT AND EVALUATION

In 1989, the EXXON VALDEZ oil spill in Prince William Sound, Alaska exposed many weaknesses in U.S. oil spill response capabilities, including the limitations of mechanical recovery equipment and systems, and the lack of the necessary logistics and training to support deployment and operation. To improve mechanical recovery capability, a major technology development and evaluation effort has been undertaken by federal agencies, as outlined in the Interagency Oil Spill Research and Technology Development Plan mandated by OPA 90. In addition, individual states and industry—including both MSRC and individual system manufacturers—have contributed to, and augmented the federal effort, often through joint projects with these agencies. New systems have been designed, prototyped, and tested at OHMSETT (re-opened for testing by the Minerals Management Service [MMS] in 1992) and at sea. This renewed technology development-evaluation effort has gained momentum in the period 1993–1998. This section summarizes progress made in improving the following systems and equipment associated with mechanical recovery:

- Oil tracking and mapping systems
- Oil containment booms and skimmers
- Pumps, oil/water separators (including emulsion-breaking systems), and temporary storage devices
- Fast-water recovery technology
- Technology for oil recovery in ice environments

### 3.2.1 Oil Tracking and Mapping Systems

To mount countermeasures and cleanup, spill extent must be located and mapped quickly, and where possible, the thicker portions of a slick must be identified. Doing this allows for efficient deployment of mechanical recovery resources, as well as dispersant application systems and *in situ* burn equipment. Once on-scene, response units must be appraised of and vectored to the higher concentrations of oil to be effective. Spill reconnaissance is critical to the success of all three response techniques – mechanical recovery, dispersant application and in-situ burning. Although not currently required in regulation, this spill reconnaissance is critical to the success of all three-response options.

Visual observation from aircraft is the most common means of providing this reconnaissance. This involves the use of observers, trained using the NOAA Oil Observer guide or through similar methods, and experienced in observing and reporting on the relative thickness of oil patches on water spread over wide areas after a spill. To be effective, the aircraft should be capable of providing continuous observation of the spilled oil during daily hours. The observer should not have a role in the safe operation of the aircraft. The observer should be in continuous direct communication with on-water recovery resources and with command and control personnel directing those resources.

In addition to visual observation from aircraft, there are several technologies that have been used in tracking and mapping spills, particularly during periods of low visibility: oil tracking buoys, airborne oil spill remote sensing, and satellite remote sensing. Fingas and Brown (1995, 1996, 1997) and Brown and Fingas (1996) summarize recent technology development and evaluation efforts for oil spill remote sensing. Fingas *et al.* (1995a) summarize recent experience in operational use. Brown and Fingas (1999) provide an overview of the airborne remote sensing platforms and sensor suites in use around the world. The current status of oil spill tracking and mapping technology is summarized in Table 3-1.

**TABLE 3-1.** Summary of Oil Spill Tracking and Mapping System Development and Application.

| EQUIPMENT | GENERAL APPLICATION | OPERATIONAL CONSIDERATIONS | CURRENT STATUS |
|---|---|---|---|
| Oil spill tracking buoys | Strategic planning | Provides initial indication of slick speed and direction | No recent improvements. Testing continues. |
| SLAR | Wide-area detection and mapping | Ineffective in sea states > 3. Susceptible to false targeting. | Remains static. Older technology. |
| SAR | Wide-area detection and mapping | Ineffective in sea states > 3. Susceptible to false targeting. | X-Band Radar shows promise. Expensive; requires dedicated aircraft. |
| IR sensors | Detection, tactical mapping, thickness can be inferred | Can detect chemicals as well as oil. Systems inexpensive and portable. | Development of an aircraft-of-opportunity system underway. System would include UV sensor and incorporate GPS data. |
| UV scanners | Detection | Detects thinner slicks than IR sensor. Susceptible to false imaging. | Best used in combination with IR sensor to produce overlay. No recent improvements. |
| Laser fluorosensor | Positive detection and identification as oil | Can be operated in conjunction with other sensors to identify and map slicks. | Environment Canada has an operational prototype (LEAF system), which has been fully tested and used operationally |
| Laser acoustic sensor | Slick thickness | Best used to calibrate other sensors. | R&D stage only. No operational prototype available. |
| Frequency scanning radiometer | Slick thickness | If successful, could operate at night and in any weather | R&D stage prototype tested at OHMSETT. No operational unit available. |
| Satellite remote sensing | Wide-area mapping | Intermittent coverage limits tactical operational use. | Still being investigated as future reconnaissance tool. |

Note: SLAR, Side-Looking Airborne Radar; SAR, Synthetic Aperture Radar; IR, infrared; UV, ultraviolet; GPS, Global Positioning System; LEAF, Laser Environmental Airborne Fluorosensor; R&D, research and development; OHMSETT, Oil and Hazardous Material Simulated Environment Test Tank.

Using oil spill tracking buoys has been investigated for a number of years. Early tracking buoys relied on radio signal tracking to mark buoy position (and hopefully a slick). Current versions rely on satellite/Global Positioning System (GPS) to track movement. Recent testing efforts of oil spill tracking buoys (Goodman *et al.*, 1995; Reed *et al.*, 1993) show that a tracking buoy will move with or diverge from an oil spill depending on buoy configuration and oil condition (e.g., emulsified or dispersed). These tracking buoys are best suited for marking the location of a spill initially, and providing a global estimate of drift speed and direction. They have limited utility as a tactical spill-tracking tool.

Of greater utility for oil spill response operations management is airborne oil spill reconnaissance, using both visual observation and remote sensors. In most cases, visual observations provide much oil spill reconnaissance data, but are limited to daylight and good visibility. Oil spill remote sensors offer the advantage of tracking and mapping oil at night and in poor visibility. Radar systems—Side-Looking Airborne Radar (SLAR) and Synthetic Aperture Radar (SAR)—have the ability to detect surface oil slicks, but are susceptible to false targets. X-Band Radar is most effective; standard search radar systems are much less effective. These radar systems are expensive to build and operate (SLAR, $700,000–$1 million; SAR, $2 million–$4 million) (Fingas *et al.*, 1996).

IR sensors and UV scanners are more useful for tactical reconnaissance. IR sensors are capable of detecting oil on the water surface and qualitatively identifying thicker portions of a slick. UV scanners are more susceptible to interference and false imaging, but can be used in combination with infrared to produce IR/UV overlays that provide a more positive identification of oil than either technique alone. The major technological advance over the past few years is the reduction in size and cost of IR sensors: small, portable units can now be obtained for under $100,000 and weigh less than 50 kg. Thus, infrared is becoming the primary remote-sensing tool for spill response.

A major problem in oil spill remote sensing is positively identifying oil as opposed to a myriad of other substances and phenomena that can be mistaken for an oil slick (e.g., kelp and wind shadow). As hydrocarbons on the water exhibit unique fluorescence properties, fluorosensors have the ability to identify oil positively. In recent years, Environment Canada has been successful in developing a scanning laser fluorosensor, which scans the sea surface or shoreline quickly and identifies oil with high accuracy and resolution (Brown *et al.*, 1995, 1996, 1998). It is also the only tool for detecting oil in ice. The unit has been fully developed, with operational prototypes tested on oil spills in a test basin and at sea. The current cost of the system is approximately $500,000, and two operational units are available from Environment Canada (*Personal communication*, M. Fingas, Emergencies Science Division, Environment Canada, Ottawa, Ontario, December 1998).

Measuring oil spill thickness is a key parameter for planning spill response operations. Unfortunately, oil spill thickness sensors remain in the R&D stage. A prototype microwave radiometer oil thickness sensor has been developed and tested by the USCG (McMahon *et al.*, 1995). A promising laser-acoustic technique has been developed and is being tested by Environment Canada (Brown *et al.*, 1997); however, it appears that an operational prototype of such a device is still several years away.

Satellite imagery continues to be used on major spills where coverage is available; however, coverage is often intermittent during response operations, thereby limiting the utility of satellite remote sensing as a tactical reconnaissance tool. The limitations of satellite remote sensing as compared with aerial remote sensing are described by Fingas *et al.* (1998). However, satellite remote sensing is valuable in providing a synoptic view of the overall area affected by the spill. Several European countries (Germany, The Netherlands, Norway and Denmark) are now using the Synthetic Aperture Radar provided by the ERS-1 and 2 satellites in conjunction with their aircraft-based oil spill reconnaissance systems (Brown and Fingas (1999).

Integrating these sensors into an airborne system remains a complex and expensive undertaking. A number of systems have been assembled and are in operation around the world as reported by Brown and Fingas (1999). Because of their cost and complexity, they are exclusively owned and operated by government agencies. In the U.S. and Canada, the U.S. Coast Guard, Canadian Coast Guard, and Environment Canada operate airborne oil spill remote sensing systems. There are no comparable industry-owned systems available.

*In summary*, whether through visual observation by spotter aircraft or through the use of remote sensing systems, oil tracking enhances oil recovery by allowing more precise direction of response resources to the thickest portions of the oil. Remote sensing systems allow tracking of oil at night and in certain adverse weather conditions, which render visual observation unusable. However, remote sensing equipment is still not capable of determining oil thickness, so that it can't be readily used to direct resources to heavier oil concentrations. Remote sensing equipment, except for hand-held IR cameras, is not routinely available commercially, most remote sensing assets are extremely expensive and belong to various government agencies. Hand-held IR cameras are more suitable for surveillance and detection than for routine monitoring of clean-up operations during daylight hours.

The effectiveness of oil tracking measures is often more dependent on the type of oil and prevailing environmental conditions than the general performance characteristics of the sensor or system used. It would therefore be very difficult to adjust precisely current Caps requirements based on upgrades in tracking and mapping technology. It would also be difficult to require vessel and facility plan holders to maintain a specific remote sensing mapping and tracking capability because of the limited availability, high cost, and minimal added benefit of the more complex sensors and systems.

Visual observation from aircraft, however, remains critical to effective employment of spill response resources to the thickest portions of the oil. The first resource that responders usually require in many cases is the ability to reconnoiter the spill from the air. Therefore, it is important that the resources be available in advance. Secondly, the original Caps were limited in part due to the difficulties in effectively tracking multiple response operations simultaneously. Dedicated aerial surveillance will accommodate employment of more resources over a wider area because visual observation will allow greater command and control. Visual observation from the air is essential for the effective deployment of dispersant and *in situ* burning resources because of the need to monitor those operations for effectiveness and visually observable effects. Likewise for mechanical recovery, the guaranteed availability of visual observation resources will allow for greater coordination of response resources. This in turn will result in increased effectiveness of those resources, as they will be able to move between the heaviest concentrations of oil much more efficiently producing much higher encounter rates and greater skimmer efficiency.

Therefore, plan holders could be required to have available, by contract, sufficient aircraft and trained observers to provide continuous observation of spill response operations up to 50 nmiles from shore and in remote areas. Observers would be expected to be in communication with response resources on the water, and, when appropriate, to act to direct the movement of these resources during the response.

### 3.2.2 Oil Containment Booms and Skimmers

The primary pieces of mechanical recovery equipment are containment booms and skimmers. They can be deployed separately or be integrated into a single system for use on a vessel of opportunity or a dedicated OSRV. Over the past several years, oil containment technology has remained relatively static, with no significant advances in fundamental concepts and approaches. Most development and evaluation effort has been in integrating containment and recovery devices (with particular emphasis on the VOSS approach) and refining the technology to allow for containment and recovery operations at higher tow speeds. The increase in tow speed is significant in that it increases the amount of oil that can be gathered and made available to a skimmer (i.e., encounter rate), which is the main limiting factor in mechanical recovery operations. Previous testing and experience indicate that limiting tow speed (or water current velocity if a boom is stationary) for effective containment is 0.75 kts. Recent modified boom designs such as the NOFI Vee-Sweep and similar designs, however, have pushed effective operating speed above 1 kt and toward 1.5 kts, which represents a significant improvement in the overall ability to recover oil in open water. Several experimental designs also are being developed at the Universities of Rhode Island, Miami, and New Hampshire, as well as by industry. These R&D efforts may push the effective tow speed even higher.

Table 3-2 summarizes recent boom testing efforts in OHMSETT and at sea. In addition to increases in effective tow speeds, current boom designs are showing better wave conformance characteristics and can operate effectively in 2–3 ft seas. Further testing at sea also is leading to improvements in boom durability and deployability.

As with containment boom, development and evaluation of skimmers continue to be incremental, with much effort devoted to refining pre-existing designs. Schulze (1998) provides a comprehensive performance review of various skimming systems that have been tested over the past twenty-five years. Although the review shows that skimming technology is well advanced, it is difficult to quantify the increase in performance capability, as skimmer testing has been intermittent with little testing being conducted during the 1980s. Most of the test data for the more common systems date back to the mid-1970s. The skimming systems tested in the early 1990s following the EXXON VALDEZ spill use the same concepts as previous models, but have different design configurations. This make direct comparisons of the Oil Recovery Rate for different skimmers, tested at different times and different test facilities, somewhat misleading . To attempt to quantify the overall progress in skimmer development over five years is difficult at best.

**TABLE 3-2.** Testing of Containment Booms.

| **DATE/ LOCATION** | **ITEMS** | **RESULTS** | **REFERENCES** |
|---|---|---|---|
| June 1997/ OHMSETT | University of Miami Oil Boom EIS | First oil loss tow speed: 1.23 kts w/ EIS nets, 0.83 kts w/out EIS nets | Coyne, 1997 |
| 1997/ OHMSETT | University of New Hampshire Rapid Current Boom | Throughput efficiency:<br>70%–99% with Sundex 8600 oil<br>40%–64% with Hydrocal 300 oil | Swift *et al.*, 1997 |
| November 1995/ OHMSETT | Pacific Link Multi Boom | Throughput efficiency: 30% at > 2 kts<br>Failed to efficiently recover oil at > 2 kts | Nash *et al.*, 1997 |
| May 1994/ At sea | USCG, Oil Stop, Inc. | Tow speed at full boom submergence: 2.5 kts<br>Conformed well to waves | Nordvik *et al.*, 1995a |
| | USN, Dunlop Model USS-42 | Tow speed at full boom submergence: 1.5–2.0 kts<br>Did not conform to waves | |
| | Norlense A/S Barrier Boom NO-1370-R | Did not submerge up to 3.5 kts tow speed<br>Conformed well to waves | |
| November 1993/ OHMSETT | USCG VOSS Skimming System with Flexi Boom | Critical tow speed: 1.8 kts (calm water)<br>First loss tow speed: 1.05 kts (heavy oil)/1.0 kts (lower viscosity oil)<br>Gross loss tow speeds: 1.28–1.4 kts | Goodwin *et al.*, 1994 |
| October 1992/ OHMSETT | NOFI Vee-Sweep 600 | Critical tow speed: 3.4–3.6 kts (full submergence)<br>First loss tow speed: 1.1 kts (Hydrocal 300), 1.4 kts (Sundex 8600)<br>Gross loss tow speed: 1.35–1.8 kts | Goodwin *et al.*, 1993 |

Note: OHMSETT, Oil and Hazardous Material Simulated Environment Test Tank; EIS, Entrainment Inhibitor System; kts, knots; USCG, U.S. Coast Guard; USN, U.S. Navy; VOSS, vessel-of-opportunity skimming system.

Table 3-3 summarizes recent tank and at-sea testing of skimming systems. The most significant efforts involve the integration of higher-speed containment booms with skimmers to form more capable VOSSs. The USCG has been active in developing VOSS for the new class of buoy tenders, thus setting the standard for VOSS technology, as it did in the 1970s with the development of the high seas skimming barrier for open-ocean spill recovery. This testing also has encouraged manufacturers to develop more capable, higher-speed skimming systems, several of which have been tested at OHMSETT.

**TABLE 3-3.** Testing of Skimming Systems.

| DATE/ LOCATION | ITEMS | RESULTS | REFERENCES |
|---|---|---|---|
| October 1997/ OHMSETT | JBF DIP 600 High Speed Skimmer | Throughput efficiency: 76% (Sundex 8600 oil in waves.)<br>ORE: 59.2–84.2% | DeVitis *et al.*, 1998 |
| November 1996/ OHMSETT | Marco VOSS 19 Skimmer | Max ORR: 281 gpm (3.5 kts, calm water), 16–281 gpm range | *High Speed Skimmer Tests at OMHSETT* [draft report], 1996 |
| | JBF DIP 3003 Skimmer | ORR: 24–158 gpm | |
| | Lori Brush Pack | ORR: 4–40 gpm | |
| | Webster Barnes Induction Bow Skimmer, HIB 20 | ORR: 325 gpm (3 kts, calm water) | |
| August 1996/ OHMSETT | O.S.R. Systems COV-400 (Prototype) | ORR: 216 gpm (1 kt, calm water)<br>ORE: 12% in waves, 64% in calm water | Nash and Cunneff, 1997 |
| June 1996/ OHMSETT | JBF DIP 1300 Oil and Debris Skimming System | ORE: 72–98% (Sundex 8600 oil), 23-42% (Hydrocal 300 oil)<br>ORR: 221 gpm (high viscosity, waves)<br>Critical tow speed: >3 kts | Nash *et al.*, 1996 |
| | Hyde/Desmi Skimming System | ORE: 42–77% (Sundex 8600), 74–85% (Hydrocal 300)<br>ORR: 221 gpm (Sundex 8600, waves)<br>Critical Tow Speed: 2.9 kts | |
| August 1993/ OHMSETT | LORI LSC-2 Skimming System | ORR: 2.7 (calm)/3.0 (waves) gpm (fine brush, medium oil) 7.7 gpm (fine brush, heavy oil), 9.4 gpm (coarse brush, heavy oil) | McClave *et al.*, 1993a |
| April and June 1993/ Outdoor test tank | Morris MI-30 (Disc) | Nameplate: 130 gpm<br>Optimum test rate: 42 gpm (emulsion) | Solsberg and Verjee, 1994 |
| | Ro-Desmi Ro-Disc 15 (Disc) | Nameplate: 86 gpm<br>Optimum test rate: 7 gpm (diesel) | |
| | Vikoma Komara 30K (Disc) | Nameplate: 130 gpm<br>Optimum test rate: 9 gpm (crude oil) | |
| | Vikoma T18 (Disc) | Nameplate: 80 gpm<br>Optimum test rate: 30 gpm (emulsion) | |
| | Pharos Marine AB Harbour Mate (Weir) | Nameplate: 89 gpm<br>Optimum test rate: 6 gpm (diesel) | |
| 1992/ At sea | Frank Mohn A/S Transrec Skimmers | Emulsion recovery rate: 770 gpm/hr @ 80% efficiency | Provant, 1992 |
| October 1992/ OHMSETT | RSTERU | ORR: 66–145 gpm (calm water), 10–112 gpm (waves)<br>ORE: 49–82% (calm water), 18–64% (waves) | McClave *et al.*, 1993b |

**TABLE 3-3.** Testing of Skimming Systems (*Continued*).

| DATE/ LOCATION | ITEMS | RESULTS | REFERENCES |
|---|---|---|---|
| April 1992/ Indoor test tank | LORI skimmer w/ two brush chains | Max recovery rate: 19 gpm (Bunker A) | Guénette and Buist, 1993 |
| 1991/ At sea | MOD (OSRV – not self-propelled) | 528,400 gpm storage<br>90% recovery in calm seas<br>65% recovery in stern seas | Clauss and Kühnlein, 1991 |
| | MPOSS (OSRV – self-propelled) | 79,290 gpm storage | |
| | Luhring twin-hull system | 208,718 gpm storage | |
| 1991/ Outdoor test pit | Foxtail rope mop | Optimal in medium viscosity oils, much less effective on diesel, “excellent potential for oil-in-ice applications” | Solsberg and McGrath, 1992 |

Note: OHMSETT, Oil and Hazardous Material Simulated Environment Test Tank; DIP, Dynamic Inclined Plane; ORE, oil recovery efficiency; VOSS, vessel-of-opportunity skimming system; ORR, oil recovery rate; gpm, gallons per minute; kts, knots; RSTERU, RST Systems Inc. Emergency Response Unit; MOD, Mobil Oil Dike; OSRV, oil spill recovery vessel; MPOSS, Multi-Purpose Oil Skimming System

Although the overall recovery capability of skimmers has not improved dramatically over models available before 1993 (e.g., USCG-ODI Skimming Barrier System, Transrec System, Marco, and JBF Skimmers). However, the integration of these systems with various boom configurations has resulted in improving their performance in faster currents.

In summary, recent design efforts for containment boom and skimmers have concentrated on increasing tow speeds, which will lead to higher oilrecovery rates in fast water areas, when the newly commercially availablefast-water systems are procured (See Section 3.3.4). Conventional mechanical equipment, however, has not increased significantly since 1993 in terms of recovery capacity or efficiency. Thisis true despite the fact that improved temporary storage systems are being added to equipment inventories at thetime. While improved storage units are more readily available to supportskimming units, actual recovery rates are still limited by skimmermechanics and pump rates. Therefore, any increase in recovery capacitywill require an addition of recovery equipment to the existing stock. As the efficiency of skimming devices has not improved much either, any increases in skimming equipment will continue to require an additional increase in storage at the existing 2:1 (storage/EDRC) ratio. Available data does indicate that there is sufficient equipment in oilspill contractor inventories to support a CAP increase now and in the future interms of recovery devices and temporary storage.(Note: the inventory of improved fast water systems is low at this time.) Further, advances in oil spill tracking and improvements in incident command and control with the establishment of spill management teams and the incident command system, support the effective employment of a greater number of response resources than was feasible five years ago. Therefore, a Cap increase is practicable.

### 3.2.3 Pumps, Oil/Water Separators, and Temporary Storage Devices

Once oil has been removed from the water surface, it must be transferred, processed, and/or temporarily stored for transport to shore (see discussion on page 3-5). This aspect of mechanical recovery often causes a bottleneck in response operations. Pumping high-viscosity, weathered oil was a serious problem during the EXXON VALDEZ spill, as well as other major spills. During the past few years, advances have been made in this technology, with development and/or evaluation of improved transfer pumps, oil/water separators, and temporary storage devices. Recent testing efforts are summarized in Table 3-4.

**TABLE 3-4.** Testing of Pumps, Oil/Water Separators, and Temporary Storage Devices.

<table>
<tr><th>DATE/<br>LOCATION</th><th>ITEMS</th><th colspan="3">RESULTS</th></tr>
<tr><td>April 1995/<br>OHMSETT</td><td>Canflex TSD<br>Loading and<br>Offloading Tests</td><td colspan="3">Best offloading with submersible pump through center access port. Lifting enhances offload. DOAS offload pump effective.</td></tr>
<tr><td rowspan="2">January 1995/<br>At sea</td><td>Framo TK-6<br>Centrifugal Pump<br>w/Graham Rec<br>skimmer</td><td colspan="3">Screw capacity: 2363 gpm<br>Debris tolerance: 1.6 in</td></tr>
<tr><td>Desmi DOP 250<br>Archimedes Screw-<br>type Pump w/<br>Graham Rec skimmer</td><td colspan="3">Screw capacity: 594 gpm<br>Debris tolerance: 2.0 in</td></tr>
<tr><td>May–June 1994/<br>OHMSETT</td><td>Lancer Barge TSD<br>Separation and<br>Decanting Tests</td><td colspan="3">Oil separate quickly, not affected by waves.</td></tr>
<tr><td>1994/<br>MSRC<br>Aboard ship</td><td>MSRC ACS<br>Industries separator<br>aboard VIRGINIA<br>RESPONDER</td><td colspan="3">Eight separate tests conducted with different oils and separation conditions<br>Influent rate of 147 to 506 gpm<br>Average oil content 10–30 ppm</td></tr>
<tr><td rowspan="5">October–<br>December 1992/<br>Test tank<br>Navy, USCG,<br>MSRC</td><td rowspan="5">Oil/water separators</td><td>Model</td><td>Capacity</td><td>Max oil in water effluent</td></tr>
<tr><td>Alfa-Laval</td><td>65 gpm</td><td>442 ppm</td></tr>
<tr><td>Surge Tank</td><td>250 gpm</td><td>52%</td></tr>
<tr><td>Vortoil</td><td>250 gpm</td><td>178 ppm</td></tr>
<tr><td>Intr-Septor 250</td><td>155 gpm</td><td>3%</td></tr>
<tr><td>1992/<br>RST Systems<br>Inc. unit<br>OHMSETT</td><td>RST Systems Inc.<br>skimmer tested for<br>oil/water separation</td><td colspan="3">Recovery rate/oil in effluent<br>Calm water: 104 gpm with 7 ppm in effluent<br>Waves: 45 gpm with 28 ppm in effluent</td></tr>
<tr><td rowspan="3">September–<br>October 1991/<br>Test tank<br>CEDRE</td><td rowspan="3">Oil/water separators</td><td>Model</td><td>Capacity</td><td>Max oil in water effluent</td></tr>
<tr><td>CYCLOIL</td><td>26.9 gpm</td><td rowspan="2">< 1%</td></tr>
<tr><td>SEPCON</td><td>348 gpm</td></tr>
</table>

Note: USCG; U.S. Coast Guard; MSRC, Marine Spill Response Corporation; gpm, gallons per minute; ppm, parts per million; CEDRE, Centre for Documentation, Research, and Experimentation into Accidental Pollution of the Water; OHMSETT, Oil and Hazardous Material Simulated Environment Test Tank; TSD, Temporary Storage Devices; DOAS, Desmi Offload Adapter System.

Some progress has been made in the development of portable, efficient oil/water separators that can be used to remove water from the skimmer effluent on-scene prior to transfer to a storage device. In 1992, the USCG and MSRC sponsored tests at the Naval Civil Engineering Center at Port Hueneme, California to test four devices against a target specification of 250 gpm capacity; 4,000–6,000 lb weight; 114 sq ft deck footprint; and 125 cu ft volume.

Although none of the tested units fully met the specification, three units were competitive in capacity and effluent oil concentration. Specific modifications were recommended. The tests represented the first step forward in this technology in many years. In addition to stand-alone oil/water separators, oil/water separation systems and emulsion-breaking systems have been integrated into the USCG buoy tenders carrying VOSS and MSRC responder vessels.

Extensive at-sea and OHMSETT testing was performed on two state-of-the-art temporary storage devices: Canflex Towable Bladder and Lancer Barge. Both have proven successful and are being integrated into spill response inventories in the private sector. U.S. Navy Supervisor of Salvage (SUPSALV) and MSRC also have performed extensive testing of the Dunlop Dracones (oil bladders) and the Engineered Fabrics oil bladders.

*In summary*, there has been progress in the development and evaluation of oil/water separation systems and temporary storage devices. Data from the NSFCC report indicates that additional temporary storage equipment is now available in spill response contractor inventories and has improved in its mobility. These improvements should support the deployment of more skimming units, making a cap increase (i.e., additional skimming units) practicable. Most mechanical recovery operations, however, remain hindered by booming and skimming limitations rather than by storage capacity limitations. Therefore, improvements in storage capacity alone are not likely to result in a significant increase in mechanical recovery capability. Thus a caps increase should maintain the current storage to EDRC ratio of 2:1. While there has been some improvement in oil/water separation systems, this type of technology has not been widely procured and is not generally available in most recovery systems. In situations where large recovery units, such as OSRVs, have successfully demonstrated that installed separation systems have improved their ability to store recovered oil, allowances have been granted through the OSRO classification process to increase the level of credit given to these particular units. Situations such as these, however, do not support a generic credit or offset relating to separator systems with respect to either EDRC or storage requirements.

### 3.2.4 Fast-Water Response Technology Development

Oil spills in fast-moving water (above 1 kt) are difficult to control and recover because of the ease at which oil mixes with water and entrains under booms and skimmers. A lack of effective fast-water containment and recovery systems, mooring problems, logistical complications, and limited training and experience in these difficult and dangerous response conditions have hampered response efforts in high currents on rivers.

Although 69% of oil transported on U.S. waterways is in currents that routinely exceed 1 kt, very little research has been conducted on new technologies and strategies. A recent USCG study of fast-water recovery found that in the 12 commercially active waterways surveyed, there are 234 facilities with an average WCD scenario of 4.6 million gals of oil. In the past 6 years, 58% of all oil spills 100 gals and larger occurred in fast-current water bodies, representing 4.5 million gals of oil spilled in waterways with currents that routinely exceed 1 kt (Coe and Gurr, 1998). Figure 3.2 (taken from Coe and Gurr, 1998) shows the distribution of fast-current waterways around the country and provides values for the seasonal high river surface current velocities and maximum coastal tidal current velocities. Many of the fast-current areas are encountered in rivers, although tidal inlets often present a challenging fast-current environment as discussed by Hayes, *et. al*., (1999). It is difficult to recover oil in these conditions before environmental damage occurs.

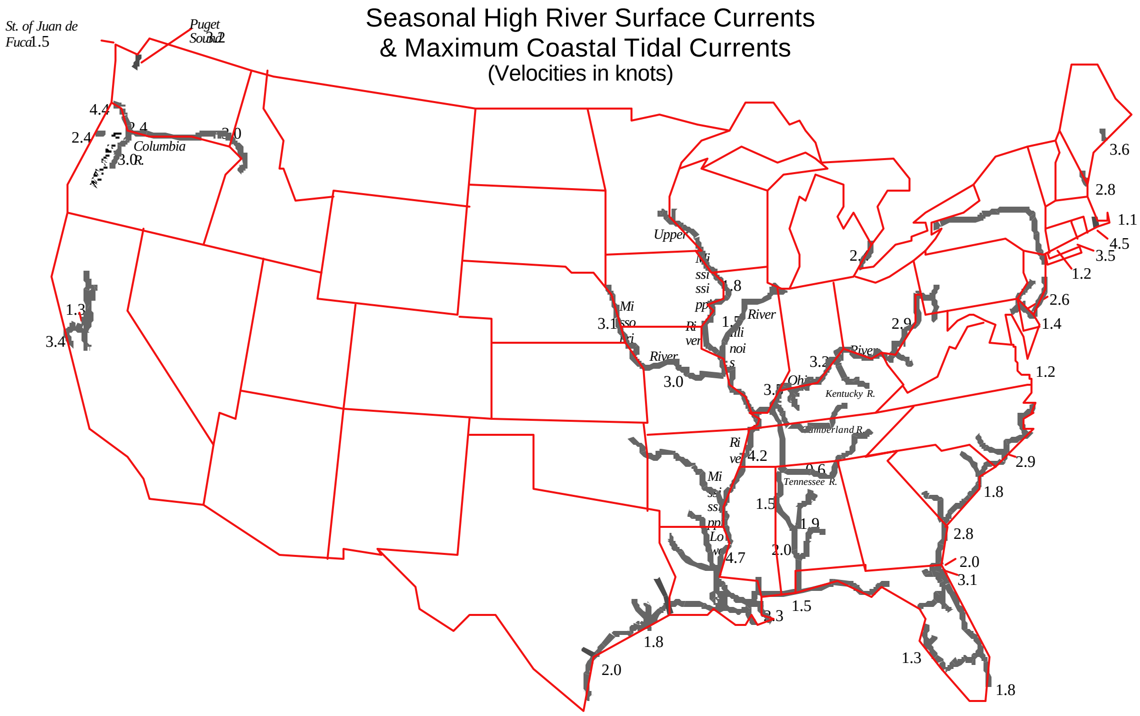


**FIGURE 3-2.** River and Coastal Currents (Coe and Gurr 1998)

Several modern skimming systems (Marco Voss 19, JBF 3003, Lori Brusk Pack, and Webster Barnes HIB 20) were tested at OHMSETT in 1996 and achieved recovery rates between 40 and 236 gpm at tow speeds of 3 knots (MAR, 1996). These systems are listed as being commercially available with the exception of the JBF 3003 system (Schulze, 1997), and could be configured with V-shaped fast-water boom to produce a capable fast-water oil recovery system that is effective in currents from 1-3 knots. Most high-speed skimmers, however, start to lose throughput efficiency at speeds above 3 kts and as wave height increases. The skimmers that use zero relative velocity and submergence plane technology tend to be more effective in higher currents and waves than surface-slicing type skimmers. Quiescent zone skimmers provide a lagoon for skimming oil. As current speeds increase above 3 kts, most skimmers cannot use deflection systems because of high drag forces, wave amplification, and turbulence, and therefore have extremely limited sweep width and low encounter rate.

Specialized boom systems also have been used in fast water. V-shaped booms, which are held in place with a net across the foot of the boom, have been effective at 1.6 kts with conventional weir skimmers in the apex. Effectiveness increased to 3 kts with several different types of in-line skimmers attached to the boom apex during tests at OHMSETT. The University of New Hampshire is developing a rapid-current boom that uses submergence plane technology to trap and contain oil in currents up to 3 kts. In the USCG fast-water recovery study (Coe and Gurr, 1998), three promising fast-water skimming systems were recommended for testing at OHMSETT:

- Ro-Clean Desmi Pollcat rope mop ZRV skimmer
- Blomberg Circus quiescent zone skimmer
- Vikoma Fast Flow expanding weir skimmer

To improve the USCG high-speed skimmer, it was recommended that a deflection system be used to improve performance from 3–6 kts, and paravanes for oil deflection and concentration in high currents be developed and tested.

*In summary*, advances have been made in developing fast water booming and skimming technology, and fast water capable systems are becoming commercially available. With the right equipment and boom deployment strategies, effective recovery operations can be undertaken in currents of up to three knots. In most inland and coastal areas average currents in fast water areas are three knots or less. Therefore, a Caps increase is justifiable and practicable in fast water areas because the technology exists and the need for improved skimming efficiency in fast water areas continues to hamper response.

In encouraging establishment of fast water equipment stockpiles, Coast Guard On Scene Coordinators should work with their Area Committees to identify and delineate areas where currents average between 1 and 3 knots on the inland rivers and in coastal inlets, and where fast-water recovery operations may be necessary and practicable. General guidelines should be proposed for the equipment and deployment procedures that will be effective in these specific areas, and these guidelines published in the Area Contingency Plan. By identifying fast water areas and specifying response capability guidelines in the Area Contingency Plans, plan holders will be motivated to meet the increased equipment levels through the procurement of new “fast water” systems.

### 3.2.5 Technology for Oil Recovery in Ice Environments

The technology for recovering oil in ice-infested environments has remained static since the mid-1980s. Glover and Dickens (1999) provide an overview of the current strategies and procedures for dealing with oil spills under Arctic conditions. Mechanical recovery in light ice conditions (2–3 oktas[1]) is possible, albeit difficult, using ice diversion schemes and standard containment booms and skimmers. Rope mop skimmers are preferred because other skimmers will become clogged with smaller pieces of ice quickly. Recovery in higher concentrations of broken ice is virtually impossible. *In situ* burning is the only effective

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[1] 25%–37% in ice coverage.

countermeasure for broken ice conditions. Recovery on solid ice is possible, but again, *in situ* burning is preferred. Recovery from under ice is very difficult, if not impossible, as there is no proven technology for locating oil under ice, and gaining access to the oil is difficult. A recent contingency plan for renewed drilling operations on the North Slope recommends the same techniques as formulated during the Tier II deliberations in Alaska in the mid-1980s (EMCON Alaska Inc., 1997).

Efforts are underway to improve the technology for recovering oil in ice environments. The Mechanical Oil Recovery in Ice-Infested Waters (MORICE) project is a multinational project to develop technologies for the effective recovery of oil in ice conditions. Several prototypes have been tested so far, and further testing is scheduled to take place in the near future. These efforts, however, have not resulted in commercially available equipment at this time.

### 3.3 MARKET AVAILABILITY OF MECHANICAL RECOVERY EQUIPMENT

Technology development and evaluation do not ensure the availability of mechanical recovery equipment and systems. To have an impact on future spill response operations, equipment prototypes must be refined and made available on the open market for purchase by government and private-sector spill response organizations. Maintenance support and training must be supplied by the manufacturer and/or distributor. In addition, the system must be affordable, which generally requires that the number of devices built and sold must be large enough to be commercially viable.

The current market availability of mechanical recovery equipment and systems can be assessed by checking listings in the *World Catalog of Oil Spill Response Products* (Schulze, 1993, 1998; see also Tables/Figures B-1 to B-10 in Appendix B), which provides a comprehensive listing of oil spill cleanup products available on the commercial market, including descriptions, performance data, vendors, and cost. Equipment market availability from 1993 to 1998 is compared by looking at the number of equipment models (for containment booms, skimmers, pumps, oil/water separators, and storage devices) listed in the fourth edition of *World Catalog* (Schulze, 1993) versus the sixth edition (Schulze, 1997). The results are provided in Table 3-5.

Table 3-5 clearly indicates that the number of models available in each equipment category is on the rise. Equipment is generally available for purchase, and there should be a healthy level of competition among manufacturers to keep costs down and maintain an adequate level of support and training. Table 3-5 makes no assumptions on the net performance capabilities of the equipment, which for many of the products listed are based on the expectations and claims of the manufacturers. Based on the numbers of models listed, however, it would appear that the overall availability of oil spill equipment and systems has improved since 1993. This most likely can be attributed to the renewed national interest in oil spill response provoked by the EXXON VALDEZ spill and the regulatory requirements of OPA 90 (including the Caps in 33 CFR 155 and 33 CFR 154). It is uncertain how long the market for oil spill products will remain strong. It is also clear, however, that a strong national mandate to maintain and increase vessel and facility response capabilities (as reflected in the Caps) will support future growth and stability in the oil spill product manufacturing industry.

**TABLE 3-5.** Comparison of Mechanical Recovery Equipment Models on the Market, 1993 and 1998.

| EQUIPMENT CATEGORY | 1993 MODELS | 1998 MODELS | NEW MODELS INTRODUCED | NET INCREASE |
|---|---|---|---|---|
| Calm-water booms | 124 | 247 | 143 | 123 |
| Protected-water booms | 207 | 232 | 99 | 25 |
| Open-water booms | 74 | 108 | 58 | 34 |
| Calm-water skimmers | 164 | 222 | 99 | 58 |
| Protected-water skimmers | 113 | 185 | 122 | 72 |
| Open-water skimmers | 87 | 129 | 72 | 42 |
| Oil/water separators | 79 | 115 | 43 | 36 |
| Oil storage devices | 145 | 255 | 117 | 110 |

Note: The net increase is the number of new models entering the market minus the number of models dropped from the market.

Source: Adapted from Schulze (1993, 1997).

## 3.4 ANALYSIS OF CURRENT MECHANICAL RECOVERY CAPACITY BY GEOGRAPHIC REGION AND CAPS CATEGORY

Technology availability, and the equipment and systems that embody this technology, does not provide an adequate mechanical recovery capability within the United States. Individual pieces of equipment must be assembled into recovery systems that are capable of recovering oil in the on-water environment of a specific region. Therefore, to provide an adequate mechanical recovery capability that meets national requirements, equipment must be acquired, stationed, and maintained in necessary amounts around the country. Balance must be achieved with containment, recovery, and storage capability appropriate to the specific environments within each region. For instance, there should be an adequate supply of both coastal (19–41 in) and open-ocean (> 42 in) booms in coastal regions to respond to spills in inland, nearshore, and offshore situations. Recovery (skimmer) capacity should be matched with adequate storage capacity to ensure that neither limits the overall mechanical recovery operation. The NSFCC performed a cursory assessment of the distribution and adequacy of oil spill response resources in the United States, and response resources were tabulated on a state-by-state basis (NSFCC, 1998).

Although somewhat summary in nature, Table 3-6 shows a relatively even distribution of resources around the country, with a somewhat higher amount of assets in regions where spills are more prevalent (e.g., Gulf Coast, Northeast, and Middle Atlantic). It also shows a reasonable balance between recovery and storage capability (note that 33 CFR 155 and 33 CFR 154 call for a 1:2 ratio of recovery to storage capability to account for water recovered with oil). More importantly, the summary data in Table 3-6 suggest a regional mechanical recovery capacity that is more than adequate to meet the current Caps, as well as a 25%–50% increase (with the only apparent exception being Oceania).

**TABLE 3-6.** Summary of Mechanical Recovery Resources by Region*.

| REGION* | BOOM (FT) 6–18 IN | BOOM (FT) 19–41 IN | BOOM (FT) > 42 IN | SKIMMER EDRC (BPD) | TEMP STORAGE (BBLS) | VESSEL STORAGE (BBLS) |
|---|---|---|---|---|---|---|
| I – New England | 192,250 | 185,200 | 55,315 | 335,335 | 351,656 | 632,558 |
| II – Northeast | 491,150 | 118,100 | 54,966 | 312,740 | 298,803 | 640,943 |
| III – Middle Atlantic | 395,050 | 26,500 | 46,747 | 170,970 | 60,593 | 121,584 |
| IV – Southeast | 572,815 | 240,700 | 69,958 | 320,010 | 127,506 | 180,644 |
| IV – U.S. Caribbean | 6,000 | 60,500 | 30,583 | 83,726 | 7,164 | 639,834 |
| VI – Gulf Coast | 1,553,928 | 383,200 | 149,627 | 899,363 | 383,485 | 1,226,210 |
| Major Inland River States | 701,175 | 266,400 | 63,766 | 499,076 | 404,946 | 960,986 |
| V – Great Lakes | 290,500 | 127,050 | 29,950 | 253,481 | 361,928 | 566,603 |
| IX – California | 112,600 | 363,874 | 113,070 | 291,730 | 617,282 | 528,884 |
| X – Pacific Northwest | 3,700 | 192,000 | 61,994 | 178,354 | 138,917 | 365,255 |
| Alaska | 218,013 | 225,825 | 92,338 | 386,880 | 169,501 | 831,009 |
| Oceania | 34,000 | 24,100 | 27,653 | 48,871 | 10,978 | 215,824 |

Note: EDRC, effective daily recovery capacity; bpd, barrels per day; bbls, barrels.

* Federal (EPA) regions are defined as follows: I – New England (Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, Maine), II – Northeast (New York, New Jersey), III – Middle Atlantic (Delaware, Maryland, Virginia), IV – Southeast (North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi), IV – U.S. Caribbean (Puerto Rico, U.S. Virgin Islands), VI – Gulf Coast (Louisiana, Texas), Major Inland River States (Louisiana, Alabama, Mississippi, Arkansas, Tennessee, Missouri, Kentucky, West Virginia, Indiana, Ohio, Illinois, Pennsylvania), V – Great Lakes (New York, Ohio, Michigan, Illinois, Wisconsin, Minnesota), IX – California, X – Pacific Northwest (Oregon, Washington), Alaska, and Oceania (Hawaii, Guam).

To carry this analysis one step further, data were obtained from the NSFCC RRI on the EDRC calculated for various U.S. ports. These calculations were provided by the NSFCC for both vessels and facilities within the ports at Tiers I, II, and III. The data are displayed in Tables 3-7A–D for vessels and facilities in selected U.S. ports. The calculation procedure for EDRC is the same as that used by vessel and facility plan holders in computing their own mechanical recovery levels for meeting the Caps. The coastal ports have associated inland, nearshore, and ocean EDRC values because different types of equipment are used in each scenario. For example, some skimmer and boom designs are only appropriate for calm or protected waters. The EDRC values are lower for facilities than for vessels because facilities' required response times are shorter; thus, there is less time to transport the equipment to the scene.

The values for Tiers I, II, and III in Tables 3-7A–D essentially represent the total recovery capability from all sources that could be made available to a vessel or facility plan holder for a spill response. These EDRC values assume that the logistics assumptions inherent in making EDRC calculations are correct, such as equipment can be moved to the port in question and is not being used in other spill responses. As such, these EDRC values represent the best case estimate of resources that might be used for a spill response. It is not expected that a vessel or facility plan holder would either acquire or pre-contract for these resources, as they are far above the current or proposed Caps. It is clear, however, that a 25%–50% increase in current Caps can be accommodated with the equipment inventories available in each region.

In determining if a Caps increase is practicable for the various geographic categories, it is important to understand the impact of the projected increase on the ability to respond to a WCD scenario in various ports. While vessel and facility plan holders are required to determine their own individual WCD scenarios, many ACPs provide examples of typical WCD scenarios. Using scenarios from ACPs, the EDRC to respond to the WCDs can be calculated using the procedures in the regulations. Tables 3-8A–C compare the values of the specific WCD planning volumes for nearshore, Great Lakes, and inland areas of selected ports; the total available EDRC values for these ports at Tiers I, II and III; and calculated required levels of EDRC for response to the WCD planning volume.

The calculation procedures for the values in Tables 3-8A–C are as follows:

1. The total discharge volumes and type of oil discharged in typical WCD scenarios are taken from ACPs.

2. The total available EDRCs are based on the availability of privately owned spill response equipment that could potentially reach the Captain of the Port (COTP) zones within the time limitations (NSFCC, 1998).

**TABLE 3-7A.** Profile of Total Available Oil Removal Capacity (EDRC) for Vessels and Facilities for Nearshore Areas in Selected Coastal Ports* Based on Inland Equipment†.

| SELECTED COASTAL PORTS* | VESSEL EDRC | | | FACILITY EDRC | | |
|---|---|---|---|---|---|---|
| | **TIER I 10,000 BPD** | **TIER II 20,000 BPD** | **TIER III 40,000 BPD** | **TIER I 10,000 BPD** | **TIER II 20,000 BPD** | **TIER III 40,000 BPD** |
| Boston, MA | 788,825 | 1,817,260 | 2,728,493 | 554,663 | 1,510,723 | 2,728,493 |
| New York, NY | 971,539 | 2,157,427 | 2,739,060 | 683,062 | 1,737,872 | 2,739,060 |
| Baltimore, MD | 1,568,288 | 2,728,493 | 3,351,679 | 969,849 | 2,483,495 | 2,728,493 |
| Hampton Roads, VA | 1,811,032 | 2,704,051 | 3,340,806 | 844,616 | 2,469,732 | 2,728,493 |
| Charleston, SC | 2,051,303 | 2,696,501 | 3,323,418 | 471,811 | 2,587,758 | 2,696,501 |
| Savannah, GA | 2,005,693 | 2,696,501 | 3,319,687 | 426,686 | 2,587,758 | 2,702,343 |
| Miami, FL | 948,543 | 2,682,969 | 2,957,090 | 329,222 | 2,539,051 | 2,704,044 |
| St. Croix, USVI | 132,386 | 1,410,594 | 2,672,409 | 95,793 | 349,496 | 2,591,505 |
| Tampa, FL | 1,319,167 | 2,704,044 | 3,102,692 | 483,603 | 2,543,179 | 2,723,470 |
| New Orleans, LA | 763,539 | 2,434,683 | 3,193,302 | 441,060 | 1,902,513 | 2,993,974 |
| Morgan City, LA | 1,487,531 | 2,906,306 | 3,374,681 | 836,908 | 2,312,553 | 3,274,415 |
| Houston/Galveston, TX | 770,656 | 1,940,372 | 3,364,114 | 453,456 | 1,616,875 | 3,052,646 |
| L.A./Long Beach, CA | 368,051 | 741,109 | 1,969,320 | 253,046 | 720,802 | 1,825,227 |
| San Francisco, CA | 355,714 | 697,378 | 2,129,236 | 77,305 | 696,349 | 1,521,193 |
| Puget Sound, WA | 288,798 | 702,563 | 2,082,197 | 275,214 | 696,721 | 1,394,190 |
| Valdez, AK | 242,270 | 386,021 | 764,061 | 238,719 | 370,374 | 674,899 |

Note: EDRC, effective daily recovery capacity; bpd, barrels per day.

* Ports were selected based on geographic location, availability of total EDRC data, and accessibility of worst case discharge (WCD) scenario data.

† Total equipment available to location based on travel times from surrounding areas.

Source: Adapted from NSFCC (1998).

**TABLE 3-7B.** Profile of Total Available Oil Removal Capacity (EDRC) for Vessels and Facilities for Nearshore Areas in Selected Coastal Ports* Based on Ocean Equipment†.

| SELECTED COASTAL PORTS* | VESSEL EDRC | | | FACILITY EDRC | | |
|---|---|---|---|---|---|---|
| | TIER I 10,000 BPD | TIER II 20,000 BPD | TIER III 40,000 BPD | TIER I 10,000 BPD | TIER II 20,000 BPD | TIER III 40,000 BPD |
| Boston, MA | 788,825 | 1,817,260 | 2,728,493 | 26,026 | 796,480 | 1,723,390 |
| New York, NY | 971,539 | 2,157,427 | 2,739,060 | 26,026 | 1,017,504 | 1,928,608 |
| Hampton Roads, VA | 1,811,032 | 2,704,051 | 3,340,806 | 75,546 | 1,420,197 | 2,087,479 |
| Charleston, SC | 2,051,303 | 2,696,501 | 3,323,418 | 91,935 | 1,625,764 | 2,055,487 |
| Savannah, GA | 2,005,693 | 2,696,501 | 3,319,687 | 54,722 | 1,808,587 | 2,055,487 |
| Miami, FL | 948,543 | 2,682,969 | 2,957,090 | 125,356 | 758,548 | 2,063,030 |
| St. Croix, USVI | 132,386 | 1,410,594 | 2,672,409 | 66,643 | 112,802 | 1,233,789 |
| Tampa, FL | 1,319,167 | 2,704,044 | 3,102,692 | 100,047 | 1,213,815 | 2,076,614 |
| New Orleans, LA | 763,539 | 2,434,683 | 3,193,302 | 8,125 | 1,063,834 | 2,026,735 |
| Morgan City, LA | 1,487,531 | 2,906,306 | 3,374,681 | 60,078 | 1,249,259 | 2,209,716 |
| Houston/Galveston, TX | 770,656 | 1,940,372 | 3,364,114 | 0 | 757,901 | 2,000,092 |
| L.A./Long Beach, CA | 368,051 | 741,109 | 1,969,320 | 0 | 247,473 | 687,429 |
| San Francisco, CA | 355,714 | 697,378 | 2,129,236 | 0 | 253,168 | 330,126 |
| Puget Sound, WA | 288,798 | 702,563 | 2,082,197 | 0 | 130,035 | 526,756 |
| Valdez, AK | 242,270 | 386,021 | 764,061 | 0 | 287,627 | 367,485 |

Note: EDRC, effective daily recovery capacity; bpd, barrels per day.

* Ports were selected based on geographic location, availability of total EDRC data, and accessibility of worst case discharge (WCD) scenario data.

† Total equipment available to location based on travel times from surrounding areas.

Source: Adapted from NSFCC (1998).

**TABLE 3-7C.** Profile of Total Available Oil Removal Capacity (ERDC) for Vessels and Facilities in Selected Great Lakes Ports*.

| SELECTED GREAT LAKES PORTS* | VESSELS | | | FACILITIES | | |
|---|---|---|---|---|---|---|
| | TIER I 5,000 BPD | TIER II 10,000 BPD | TIER III 20,000 BPD | TIER I 5,000 BPD | TIER II 10,000 BPD | TIER III 20,000 BPD |
| Buffalo, NY | 1,445,449 | 2,595,249 | 3,341,112 | 891,173 | 2,225,878 | 2,740,571 |
| Cleveland, OH | 1,625,762 | 2,595,249 | 3,330,254 | 847,194 | 2,489,497 | 3,204,341 |
| Detroit, MI | 1,557,978 | 2,595,249 | 3,306,103 | 466,556 | 2,489,497 | 3,288,482 |
| Chicago, IL | 1,575,583 | 2,595,249 | 3,306,103 | 415,092 | 2,595,249 | 3,278,290 |
| Milwaukee, WI | 1,281,761 | 2,595,249 | 3,306,103 | 411,331 | 2,531,544 | 3,218,435 |

Note: EDRC, effective daily recovery capacity; bpd, barrels per day.

* Ports were selected based on geographic location, availability of total EDRC data, and accessibility of worst case discharge (WCD) scenario data.

Source: Adapted from NSFCC (1998).

**TABLE 3-7D.** Profile of Total Available Oil Removal Capacity (ERDC) for Vessels and Facilities in Selected River Ports*.

| SELECTED RIVER PORTS* | VESSELS | | | FACILITIES | | |
|---|---|---|---|---|---|---|
| | TIER I 1,500 BPD | TIER II 3,000 BPD | TIER III 6,000 BPD | TIER I 1,500 BPD | TIER II 3,000 BPD | TIER III 6,000 BPD |
| Huntington, WV | 2,096,850 | 2,595,249 | 3,327,237 | 745,422 | 2,595,249 | 3,041,608 |
| Louisville, KY | 2,270,542 | 2,595,249 | 3,306,103 | 477,350 | 2,595,249 | 3,306,103 |
| Memphis, TN | 1,784,938 | 2,848,295 | 3,342,689 | 639,006 | 2,590,154 | 3,306,103 |
| Pittsburgh, PA | 1,630,592 | 2,605,816 | 3,351,679 | 1,020,783 | 2,469,451 | 2,717,635 |
| St. Louis, MO | 1,791,673 | 2,848,295 | 3,306,103 | 341,327 | 2,595,249 | 3,278,290 |

Note: EDRC, effective daily recovery capacity; bpd, barrels per day.

* Ports were selected based on geographic location, availability of total EDRC data, and accessibility of worst case discharge (WCD) scenario data.

Source: Adapted from NSFCC (1998).

**TABLE 3-8A.** WCD Volumes, Total Port EDRC Availability, and Worst Case Spill EDRC Planning Volumes* for Vessels in the Nearshore/ Inland Areas of Coastal Ports†.

| SELECTED COASTAL PORTS† | WCD SCENARIO (BBLS / TYPE OF OIL) | TOTAL PORT EDRC | | | REQUIRED EDRC | | |
|---|---|---|---|---|---|---|---|
| | | TIER I 10,000 BPD | TIER II 20,000 BPD | TIER III 40,000 BPD | TIER I 10,000 BPD | TIER II 20,000 BPD | TIER III 40,000 BPD |
| Boston, MA | 364,000 No. 6 fuel oil | 788,825 | 1,817,260 | 2,728,493 | 38,220 | 63,700 | 101,920 |
| New York, NY | 476,190 No. 6 and no. 2 fuel oil | 971,539 | 2,157,427 | 2,739,060 | 50,000 | 83,333 | 133,333 |
| Baltimore, MD | 285,714 No. 6 fuel oil | 1,568,288 | 2,728,493 | 3,351,679 | 30,000 | 50,000 | 80,000 |
| Hampton Roads, VA | 400,000 No. 6 fuel oil | 1,811,032 | 2,704,051 | 3,340,806 | 30,000 | 50,000 | 80,000 |
| Savannah, GA | 90,000 No. 6 fuel oil | 2,005,693 | 2,696,501 | 3,319,687 | 9,450 | 15,750 | 25,200 |
| Miami, FL | 1,190 South American crude | 948,543 | 2,682,969 | 2,957,090 | 179 | 298 | 476 |
| Tampa, FL | 250,000 No. 6 fuel oil | 1,319,167 | 2,704,044 | 3,102,692 | 26,250 | 43,750 | 70,000 |
| New Orleans, LA | 1,000,000 Kuwait crude | 763,539 | 2,434,683 | 3,193,302 | 150,000 | 250,000 | 400,000 |
| Morgan City, LA | 1,000,000 Medium crude | 1,487,531 | 2,906,306 | 3,374,681 | 150,000 | 250,000 | 400,000 |
| Houston/Galveston, TX | 4,000,000 Arabian heavy crude | 770,656 | 1,940,372 | 3,364,114 | 600,000 | 1,000,000 | 1,600,000 |
| L.A./Long Beach, CA | 1,500,000 North Slope Alaskan crude | 368,051 | 741,109 | 1,969,320 | 225,000 | 375,000 | 600,000 |
| San Francisco, CA | 1,500,000 North Slope Alaskan crude | 355,714 | 697,378 | 2,129,236 | 225,000 | 375,000 | 600,000 |
| Puget Sound, WA | 833,333 North Slope Alaskan crude | 288,798 | 702,563 | 2,082,197 | 125,000 | 208,333 | 333,333 |
| Valdez, AK | 2,200,000 North Slope Alaskan crude | 242,270 | 386,021 | 764,061 | 330,000 | 550,000 | 880,000 |

Note: WCD, worst case discharge; bbls, barrels; EDRC, effective daily recovery capacity; bpd, barrels per day.

* All EDRC volumes are based on inland/nearshore criteria.

† Ports were selected based on geographic location, availability of total EDRC data, and accessibility of WCD scenario data.

Source: Adapted from various Area Contingency Plans (ACPS) and NSFCC (1998).

**TABLE 3-8B.** WCD Volumes, Total Port EDRC Availability, and Worst Case Spill EDRC Planning Volumes* for Vessels and Facilities in Selected Great Lake Ports†.

| SELECTED GREAT LAKE PORTS† | WCD SCENARIO (BBLS / TYPE OF OIL) | EDRC | | | REQUIRED EDRC | | |
|---|---|---|---|---|---|---|---|
| | | TIER I 5,000 BPD | TIER II 10,000 BPD | TIER III 20,000 BPD | TIER I 5,000 BPD | TIER II 10,000 BPD | TIER III 20,000 BPD |
| Cleveland, OH Facility | 166,667 Petroleum or asphalt | 847,194 | 2,489,497 | 3,204,341 | 25,000 | 41,667 | 66,667 |
| Detroit, MI Vessel | 60,952 No. 4 oil | 1,557,978 | 2,595,249 | 3,306,103 | 9,143 | 15,238 | 24,381 |
| Chicago, IL Vessel | 80,000 No. 6 fuel oil | 1,575,583 | 2,595,249 | 3,306,103 | 8,400 | 14,000 | 22,400 |
| Milwaukee, WI Facility | 23,810 No. 2 diesel oil | 411,331 | 2,531,544 | 3,218,435 | 3,571 | 5,952 | 9,524 |

Note: WCD, worst case discharge; bbls, barrels; EDRC, effective daily recovery capacity; bpd, barrels per day.

* All EDRC volumes are based on inland/nearshore criteria.
† Ports were selected based on geographic location, availability of total EDRC data, and accessibility of WCD scenario data.

Source: Adapted from various Area Contingency Plans (ACPS) and NSFCC (1998).

**TABLE 3-8C.** WCD Volumes, Total Port EDRC Availability, and Worst Case Spill EDRC Planning Volumes* for Vessels and Facilities in Selected River Ports†.

| SELECTED RIVER PORTS† | WCD SCENARIO (BBLS / TYPE OF OIL) | EDRC | | | REQUIRED EDRC | | |
|---|---|---|---|---|---|---|---|
| | | TIER I 1,500 BPD | TIER II 3,000 BPD | TIER III 6,000 BPD | TIER I 1,500 BPD | TIER II 3,000 BPD | TIER III 6,000 BPD |
| Louisville, KY Vessel | 37,500 No. 6 fuel oil | 2,270,542 | 2,595,249 | 3,306,103 | 3,150 | 4,200 | 6,300 |
| Pittsburgh, PA Facility | 90,476 No. 2 diesel oil | 1,020,783 | 2,469,451 | 2,717,635 | 8,143 | 10,857 | 16,286 |
| St. Louis, MO Vessel | 80,000 No. 6 fuel oil | 1,791,673 | 2,848,295 | 3,306,103 | 6,720 | 8,960 | 13,440 |

Note: WCD, worst case discharge; bbls, barrels; EDRC, effective daily recovery capacity; bpd, barrels per day.

* All EDRC volumes are based on inland/nearshore criteria.
† Ports were selected based on geographic location, availability of total EDRC data, and accessibility of WCD scenario data.
Source: Adapted from various Area Contingency Plans (ACPS) and NSFCC (1998).

3. The planning volumes and required levels of EDRC for response to the planning volumes are calculated from the total discharge volumes using the procedures in 33 CFR 155, Appendix B for vessels or 33 CFR 154, Appendix C for facilities. The formulas are:

$$\text{planning volume} = \text{discharge volume} \times \%\ \text{on-water recovery}^{2} \times \text{emulsification factor}^{3}$$

$$\text{EDRC} = \text{planning volume} \times \text{mobilization factor}^{4}$$

For example, the Boston, Massachusetts ACP has a WCD scenario of 364,000 bbls of No. 6 fuel oil, which is a Group IV oil. From the tables in the regulations for vessels carrying Group IV oils in nearshore waters:

- Percentage of recovered floating oil = 50% (Table 3)
- Emulsification factor = 1.4 (Table 4)
- Resource mobilization factor = .40 (Table 5)

Thus,

$$\text{planning volume for Boston} = 364{,}000 \times .50 \times 1.4 = 254{,}800 \text{ bbls}$$

$$\text{EDRC for Boston} = 254{,}800 \times .40 = 101{,}920 \text{ bbls}$$

The EDRC required by federal regulations for response to a WCD scenario can be compared to the current and projected Caps by calculating the volume of oil that can be recovered on-water over the expected spill response specified by the regulations for different spill locations. For example, Table 2 of 33 CFR 154 Appendix C specifies that on-water cleanup must be sustained for at least 3 days for spills in rivers and canals. Tables 3-9A–C compare the percentage of the volume of oil that could be recovered assuming that the WCD planning EDRCs can be met, with the percentage of recovery estimates based on the current and proposed Caps levels (see Table 3-10) applied for the same length of time. For ease of comparison, the volumes recovered are expressed as a percentage of the WCD scenario planning volumes.

Several conclusions are evident when reviewing the information in Tables 3-8A–C, Tables 3-9A–C, and Table 3-10. There are adequate available mechanical recovery EDRC resources in all of the geographic areas to sustain Caps increases over 5 years. It is also clear that the Caps, even with a 50% increase in 5 years, do not match the required EDRC levels for the WCD planning volumes in many of the selected ports. This is particularly true for the nearshore/inland areas on the West Coast and in the Gulf of Mexico. Even with a 50%

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[2] % on-water recovery factor is from Table 3 of 33 CFR 155 Appendix B or Table 2 of 33 CFR 154 Appendix C.
[3] Emulsification factor is from Table 4 of 33 CFR 155 Appendix B or Table 3 of 33 CFR 154 Appendix C.
[4] Mobilization factor is from Table 5 of 33 CFR 155 Appendix B or Table 4 of 33 CFR 154 Appendix C.

**TABLE 3-9A.** Percentage of WCD Planning Volume Recovered for Nearshore Spills During Required Sustainability Period for Planning EDRC and Current and Proposed Caps in Selected Coastal Ports*.

| SELECTED COASTAL PORTS* | WCD PLANNING VOLUME (BBLS) | RECOVERED VOLUME IN 4 DAYS (% OF PLANNING VOLUME) | | | |
|---|---|---|---|---|---|
| | | PLANNING EDRC | CURRENT CAPS | PROPOSED INITIAL INCREASE | 5-YEAR INCREASE |
| Boston, MA | 254,800 | 120% | 43% | 54% | 65% |
| New York, NY | 333,333 | 120% | 33% | 41% | 50% |
| Baltimore, MD | 200,000 | 120% | 55% | 69% | 83% |
| Hampton Roads, VA | 280,000 | 120% | 39% | 49% | 59% |
| Savannah, GA | 63,000 | 120% | 175% | 218% | 262% |
| Tampa, FL | 175,000 | 120% | 63% | 79% | 94% |
| New Orleans, LA | 1,000,000 | 120% | 11% | 14% | 17% |
| Morgan City, LA | 1,000,000 | 120% | 11% | 14% | 17% |
| Houston/Galveston, TX | 4,000,000 | 120% | 3% | 3% | 4% |
| L.A./Long Beach, CA | 1,500,000 | 120% | 7% | 9% | 11% |
| San Francisco, CA | 1,500,000 | 120% | 7% | 9% | 11% |
| Puget Sound, WA | 833,333 | 120% | 13% | 17% | 20% |
| Valdez, AK | 2,200,000 | 120% | 5% | 6% | 8% |

Note: WCD, worst case discharge; bbls, barrels; EDRC, effective daily recovery capacity.

***** Ports were selected based on geographic location, availability of total EDRC data, and accessibility of WCD scenario data.

Source: Adapted from various Area Contingency Plans (ACPS).

**TABLE 3-9B.** Percentage of WCD Planning Volume Recovered for Offshore Spills During Required Sustainability Period for Planning EDRC and Current and Proposed Caps in Selected Coastal Ports*.

| SELECTED COASTAL PORTS* | WCD PLANNING VOLUME (BBLS) | RECOVERED VOLUME IN 6 DAYS (% OF PLANNING VOLUME) | | | |
|---|---|---|---|---|---|
| | | PLANNING EDRC | CURRENT CAPS | PROPOSED INITIAL INCREASE | 5-YEAR INCREASE |
| Boston, MA | 203,840 | 111% | 93% | 117% | 140% |
| New York, NY | 266,666 | 111% | 71% | 89% | 107% |
| Hampton Roads, VA | 224,000 | 111% | 85% | 106% | 127% |
| Savannah, GA | 50,400 | 111% | 377% | 471% | 565% |
| Tampa, FL | 140,000 | 111% | 136% | 170% | 204% |
| New Orleans, LA | 800,000 | 111% | 24% | 30% | 36% |
| Morgan City, LA | 800,000 | 111% | 24% | 30% | 36% |
| Houston/Galveston, TX | 3,200,000 | 111% | 6% | 7% | 9% |
| LA/Long Beach, CA | 1,200,000 | 111% | 16% | 20% | 24% |
| San Francisco, CA | 1,200,000 | 111% | 16% | 20% | 24% |
| Puget Sound, WA | 666,667 | 111% | 29% | 36% | 43% |
| Valdez, AK | 1,760,000 | 111% | 11% | 13% | 16% |

Note: WCD, worst case discharge; bbls, barrels; EDRC, effective daily recovery capacity.

***** Ports were selected based on geographic location, availability of total EDRC data, and accessibility of WCD scenario data.
Source: Adapted from various Area Contingency Plans (ACPS).

**TABLE 3-9C.** Percentage of WCD Planning Volume Recovered for Great Lakes and River Spills During Required Sustainability Period for Planning EDRC and Current and Proposed Caps in Selected Great Lake and River Ports*.

| SELECTED GREAT LAKE AND RIVER PORTS* | WCD PLANNING VOLUME (BBLS) | RECOVERED VOLUME IN 3 DAYS (RIVERS) OR 4 DAYS (GREAT LAKES) (% OF PLANNING VOLUME) | | | |
|---|---|---|---|---|---|
| | | PLANNING EDRC | CURRENT CAPS | PROPOSED INITIAL INCREASE | 5-YEAR INCREASE |
| Cleveland, OH Facility | 166,667 | 120% | 33% | 41% | 50% |
| Detroit, MI Vessel | 60,952 | 120% | 90% | 113% | 135% |
| Chicago, IL Vessel | 80,000 | 120% | 98% | 123% | 147% |
| Milwaukee, WI Facility | 23,810 | 120% | 257% | 321% | 385% |
| Louisville, KY Vessel | 10,500 | 130% | 100% | 125% | 150% |
| Pittsburgh, PA Facility | 24,429 | 130% | 43% | 54% | 64% |
| St. Louis, MO Vessel | 22,400 | 130% | 47% | 59% | 70% |

Note: WCD, worst case discharge; bbls, barrels; EDRC, effective daily recovery capacity.

***** Ports were selected based on geographic location, availability of total EDRC data, and accessibility of WCD scenario data.

Source: Adapted from various Area Contingency Plans (ACPS).

**TABLE 3-10.** Summary of Current and Projected Response Caps (bpd) for Vessels by Geographic Area.

| GEOGRAPHIC AREA | YEAR | TIER I | TIER II | TIER III |
|---|---|---|---|---|
| Oceans and inland | Current | 10,000 | 20,000 | 40,000 |
| | Initial increase | 12,500 | 25,000 | 50,000 |
| | 5-year increase | 15,000 | 30,000 | 60,000 |
| River and canals | Current | 1,500 | 3,000 | 6,000 |
| | Initial increase | 1,875 | 3,750 | 7,500 |
| | 5-year increase | 2,250 | 4,500 | 9,000 |
| Great Lakes | Current | 5,000 | 10,000 | 20,000 |
| | Initial increase | 6,250 | 12,500 | 25,000 |
| | 5-year increase | 7,500 | 15,000 | 30,000 |

Note: bpd, barrels per day.

increase in 5 years, the volumes recovered in the prescribed cleanup sustainability period using the resources specified by the Caps range from 4%–20% of the planning volume for nearshore spills, and 9%–43% for offshore spills. The current Caps are higher than the required EDRC for a WCD scenario for only two out of the 20 ports examined, but the proposed Caps increases for the Great Lakes would be sufficient to exceed the required EDRC for three out of the four ports examined. Therefore, the initial increase of 25% and another 25% in 5 years are consistent with ensuring the removal capability to meet the WCD planning requirements in selected port areas, and foster a more aggressive spill response posture throughout the nation.

## 3.5 CONCLUSIONS AND RECOMMENDATIONS

Table 3-11 provides a summary of the current status of mechanical recovery technology development, commercial availability, and cumulative recovery capability (as EDRC) for the three geographic categories. The information outlined in Table 3-11 supports the modification of the original Caps requirements as follows:

**Oceans and Inland.** The current status of technology, availability, and recovery capacities of mechanical equipment generally support an initial Caps increase of 25% and another 25% in 5 years. Mechanical recovery technology is progressing steadily, and new models are being made available. Recovery in fast water and ice is still limited, but this is not a universal problem. The current removal capability required by the Caps is generally well below the WCD planning volumes for vessels and facilities in nearshore/inland areas of coastal ports, particularly on the West Coast and in the Gulf of Mexico. The existing inventory of EDRC will not constrain an increase in Caps.

**Great Lakes.** Mechanical recovery in the Great Lakes often is similar to recovery in nearshore and offshore areas depending on weather conditions. Oil recovery under winter ice

**TABLE 3-11.** Implications of Mechanical Recovery Technology Development, Market Availability, and Overall Recovery Capacity Caps.

| GEOGRAPHIC AREA | TECHNOLOGY DEVELOPMENT | COMMERCIAL AVAILABILITY | OVERALL REMOVAL CAPACITY |
|---|---|---|---|
| **OCEANS** | Significant testing and refinement of booms, skimmers, and ancillary equipment accomplished in recent years. Technology steadily improving, particularly in systems integration (e.g., VOSS) and higher skimming speeds. An initial Caps increase of 25% and another 25% in 5 years are supportable. | Number of models of open-water booms and skimmers on the market increased significantly in 1993–1998. Caps increase is supportable. | Not inventory-limited for facilities and vessels in regional ports at Tiers I–III. Worst Case Discharge EDRC exceeds Caps even with increase. Caps increase is supportable. |
| **INLAND** | Technology for calm and protected water is highly developed. An initial Caps increase of 25% and another 25% in 5 years are supportable as response is no longer technology limited except for fast current and shallow water nearshore areas. | Number of models of calm- and protected-water boom and skimmers on the market increased significantly in 1993–1998. Caps increase is supportable. | Not inventory-limited for facilities and vessels in regional ports at Tiers I–III. Worst Case Discharge EDRC exceeds Caps even with increase. Caps increase is supportable. |
| **GREAT LAKES** | Nearshore and open-ocean technologies generally apply. Significant refinements and testing have been made. Open-water technology steadily improving. Recovery in ice during winter months remains problematic. An initial Caps increase of 25% and another 25% in 5 years are supportable. | Number of models of open-water booms and skimmers increased significantly in 1993–1998. Caps increase is supportable. | Not inventory limited. Approximately 2–3 million bpd EDRC is available at Tiers II–III. Caps increase is supportable. |
| **RIVERS AND CANALS** | Calm water recovery technology is fully developed and proven. Shallow-water and fast-current recovery technologies remain limited. Fast-water recovery systems (up to 3 kts) have been developed and tested at OHMSETT, but operational experience is limited. Recovery in moving, broken ice is extremely difficult. Caps increase is supportable recognizing that response in currents above 3 knots is not feasible. | Fast-water booms and skimmers are commercially available that can be used to configure systems capable to 3 kts. Caps increase is supportable. | Not inventory limited. Approximately 2–3 million bpd EDRC is available at Tiers II–III. Not clear that EDRC is valid for fast-current recovery scenarios. Caps increase is supportable recognizing the limitations in fast-current situations. |

Note: VOSS, vessel-of-opportunity skimming system; EDRC, effective daily recovery capacity; bpd, barrels per day; R&D, research and development.

conditions remains a problem. As with the previous geographic area, the current status of technology, availability, and recovery capacities of mechanical equipment generally support an initial increase in Caps levels by 25% and another 25% in 5 years. The current Cap are generally below the required EDRCs for WCD planning volumes, but an initial 25% increase, and a 25% increase in 5 years would be sufficient to cover the required EDRC for many of the Great Lakes ports.

**Rivers and Canals.** Mechanical recovery technology in fast-water and shallow-water situations, as well as for ice, remains limited. Oil spills in these types of conditions routinely occur in the major river systems throughout the country. The available EDRC values for the inland river port areas are well above the current or increased Caps, but these are probably based on conventional equipment, not fast-water recovery equipment. As has been shown in past spills, conventional techniques and equipment will be effective in lower-current portions of a waterway, and techniques may be adapted to allow limited recovery in fast-water environments. Fast-water recovery systems could be configured using V-shaped booms and fast-water skimmers that have been developed and tested in the past five years, that could be used effectively in currents up to 3 knots.

It would be difficult to discriminate fast-water river areas from calm-water river areas. Most river systems contain both conditions in close proximity with current velocities often varying as a function of tidal cycle and season. Adjusting the Caps requirements on a case-by-case basis would be difficult. However, to defer a Caps increase based on the limitations in fast-water areas would decrease the incentive to acquire and stage the fast-water booms and high-speed skimmers that have become commercially available. It would also remove the incentive to augment the recovery capability in areas where current speeds are lower. Accordingly, an increase in the Caps for rivers and canals is recommended, recognizing the inherent limitations on recovery in fast-water areas and in the presence of ice.

***How far have mechanical recovery systems and equipment, as well as supporting spill surveillance technology, advanced since the Caps regulations were formulated?***

- Significant advances in oil spill tracking and mapping technologies have occurred since 1993. Advances in IR photography, GPS, and computer technology will have a positive impact on the ability to deploy and manage mechanical recovery in future spills. However, visual observations remains the most economical and practical means of providing continuous monitoring of oil on the water for the purpose of direct response resources to the heaviest concentrations of oil.
- Modified boom designs have pushed the effective operating speed above 1 kts and toward 2 kts, which represents a significant improvement in the overall ability to contain and concentrate oil in open water.
- Although the overall recovery capability of skimmers has not improved dramatically over models available before 1993, the flexibility of these systems to be integrated with various boom configurations and operate in faster currents is improving.

- There has been progress in the development and testing of oil/water separation systems and temporary storage devices. Further development and implementation of these systems should streamline future mechanical recovery operations.
- Fast-current recovery systems have been developed which can be effective at current velocities up to 3 knots. It is possible that a proven fast-water containment and recovery system that is capable of operating above 3 kts will be developed in the next few years. Current mechanical recovery under these conditions, however, remains limited.
- The technology for recovering oil in ice-infested environments has remained static since the mid-1980s.

***Are modern mechanical recovery equipment and systems readily available for purchase on the open market?***

- The overall availability of oil spill equipment and systems has improved since 1993.
- A strong national mandate for maintaining vessel and facility response capability (as reflected in the Caps levels) will support future growth and stability in the oil spill product manufacturing industry.

***Are there sufficient mechanical recovery resources available around the country at present, or with a reasonable addition of resources, to meet the proposed Caps level increases?***

- In all of the Caps geographic areas—coast/harbor and open ocean areas (described in the regulations as "all except rivers and canals, and Great Lakes"), Great Lakes, and rivers and canals —the oil removal capability is not limited by the cumulative recovery resources accessible to a given port.
- It is also clear that a 25%–50% increase in current Caps levels can be accommodated easily within the existing resource inventories within each region.

***Is an increase in mechanical recovery Caps levels practicable in light of advances in technology, market availability of systems and equipment, and overall distribution of mechanical recovery resources around the nation?***

- **Oceans, Nearshore, and Inland.** Although recovery capability in fast water and ice is still limited, incremental improvements in open water recovery technology have been realized over the past five years. The removal capability required by the current Caps is generally well below the WCD planning volumes for vessels and facilities in oceans, nearshore, and inland areas of coastal ports. An increase in mechanical recovery Caps for this category is both practicable and supportable.
- **Great Lakes.** Mechanical recovery in the Great Lakes is similar to recovery in nearshore and offshore areas depending on weather conditions. Oil recovery in ice remains problematic. The removal capability required by the current Caps is generally well below the WCD planning volumes for vessels but comparable to

facility planning volumes in the Great Lakes. An increase in mechanical recovery Caps for the Great Lakes is practicable and supportable.

- **Rivers and Canals.** Mechanical recovery technology in fast-current and shallow-water situations, as well as in ice, remains limited. Conventional techniques and equipment, however, may be effective in lower-current portions of a waterway, and techniques may be adapted to allow limited recovery in fast-water environments. Tank testing at OHMSETT indicates that commercially available fast-water booms and high-speed skimmer systems could be used to provide a recovery capability in fast water up to 3 knots. The current and proposed Caps levels are below the WCD planning volumes for vessels, and somewhat below these levels for facilities. A mechanical recovery Caps increase is practicable and supportable.
- **Fast Water Technology.** Fast water technology has matured to the point that there are commercially available systems, which are capable of operating in currents of 1 to 3 knots. Federal On-scene Coordinators should work through the Area Committee process to identify fast water areas at the local level. These should be published in local area contingency plans, along with description of suitable response strategies, as an encouragement to planholders to procure and maintain fast water response equipment.
- **Oil Spill Tracking In All Operating Areas**. Oil spill tracking and mapping is critical to effectiveness and efficiency of every oil spill response technology. While electronic oil spill tracking equipment is becoming increasingly sophisticated, visual observation of oil in the water from aircraft remains the most reliable means of directing response resources during a spill. Therefore, amending the caps requirement to include maintenance of an aerial observation capability is supportable operationally and becomes practicable as well, if a dispersant capability is mandated.